Spatial Responses to Climate Across Trophic Levels:
Modeling Plants, Prey, and Predators in the Western United States

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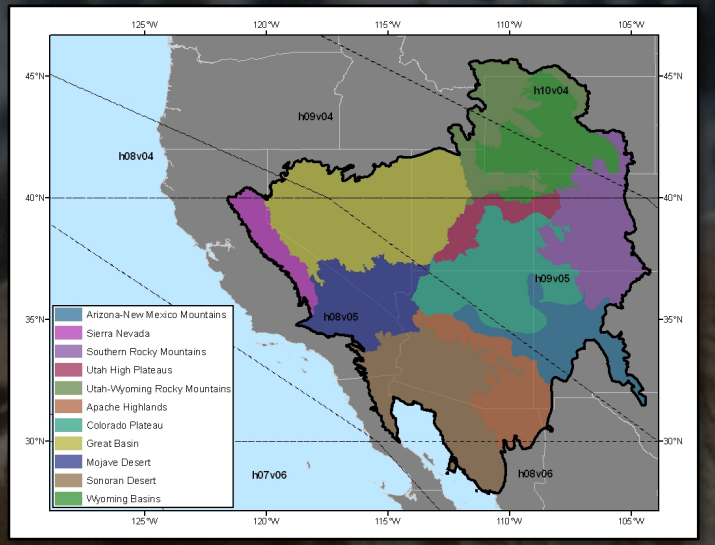
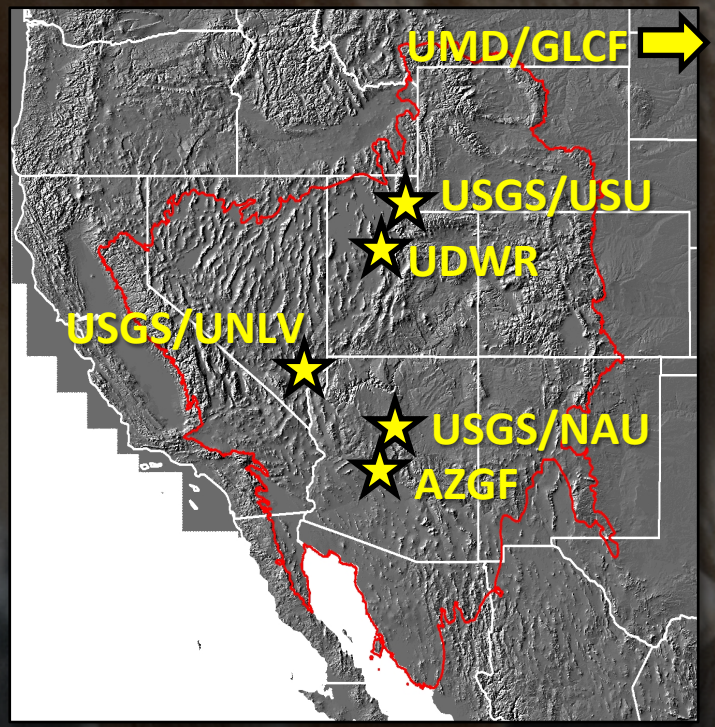
Study area & partners

- 4 species
- 7 states
- 11 ecoregions
- 19 partners
  - Universities
  - Federal agencies
  - State agencies
  - Nonprofit organizations
  - Industry





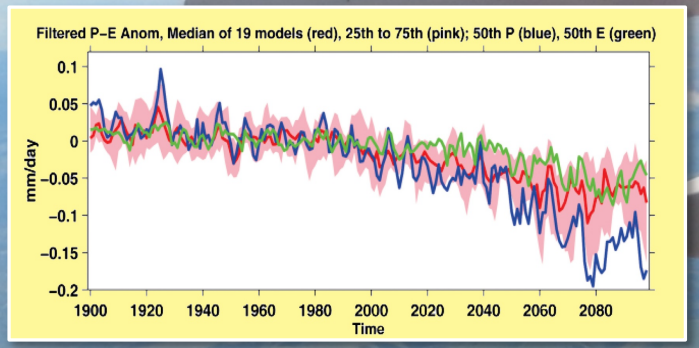

Climate changes

Land-use changes

An ecosystem in flux

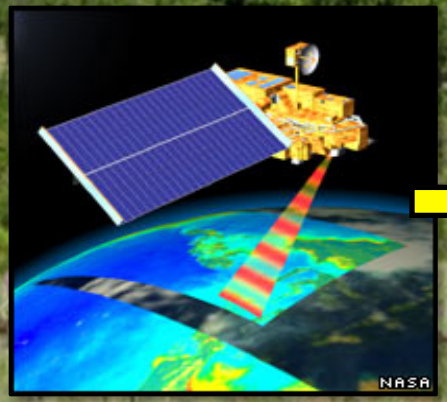
- Climate
  - Less precipitation
  - Earlier snowmelt
  - Longer growing seasons
  - More severe droughts
- Land use
  - Oil & gas drilling
  - (Sub-)urbanization
  - Agricultural expansion
  - Solar & wind farms

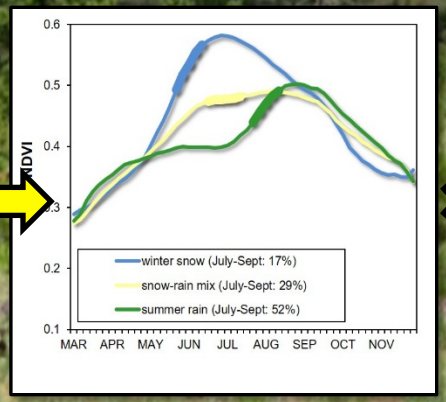
➢ *Habitat loss & fragmentation*

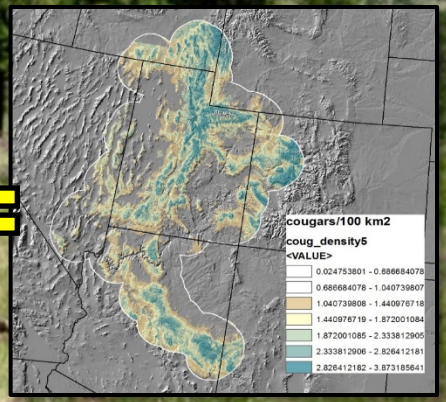


Goal: combine satellite imagery with *in situ* data to inform natural resource management

How do climate changes propagate through ecosystems?







Satellite observations **Plant phenology** **Animal locations** **Habitat & demography**

Predator Density & Distribution



Prey Density & Distribution

Management
(manipulation)

No control
(prediction)

CARNIVORES

HERBIVORES

PLANTS

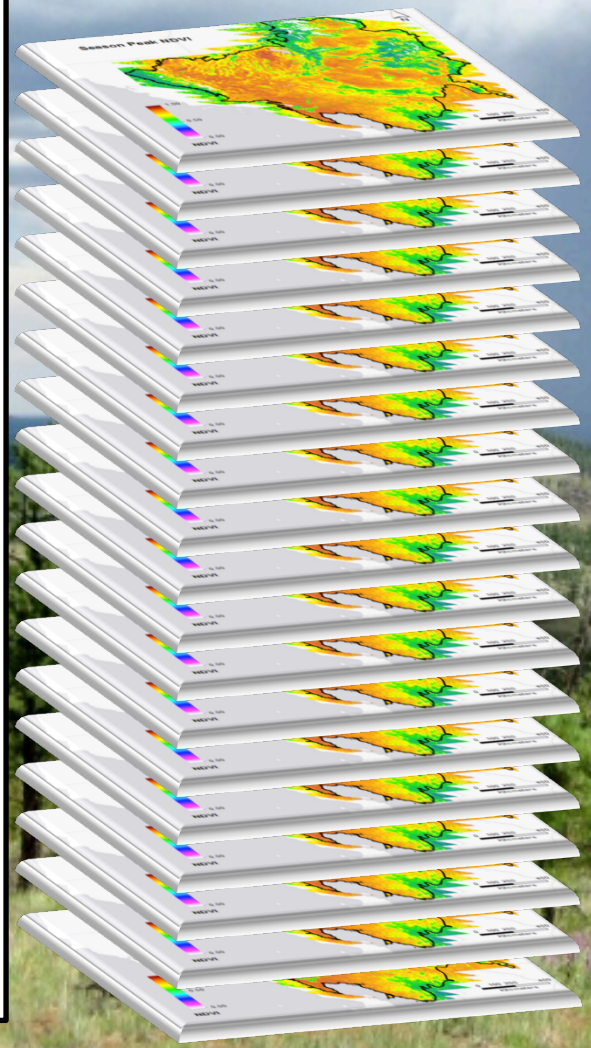
CLIMATE

YEAR

2014

(1 Jan 2000 - 31 Dec 2014)

2000

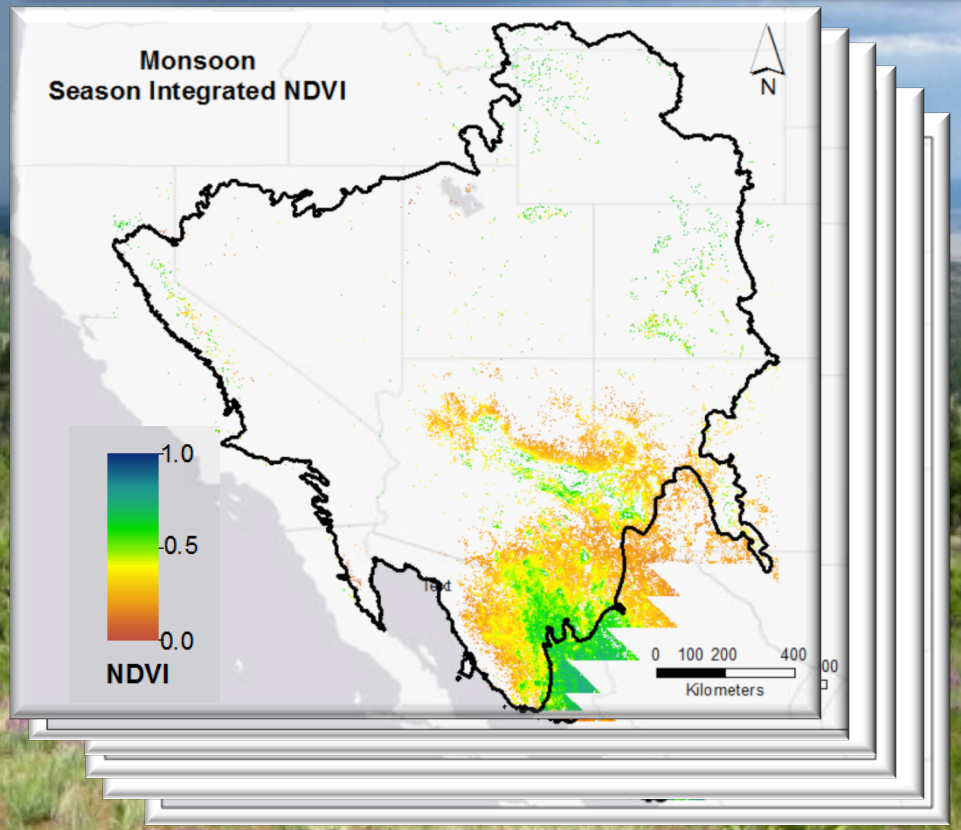


Plant productivity & phenology: NDVI

MODIS Surface Reflectance

(daily, 500 m)

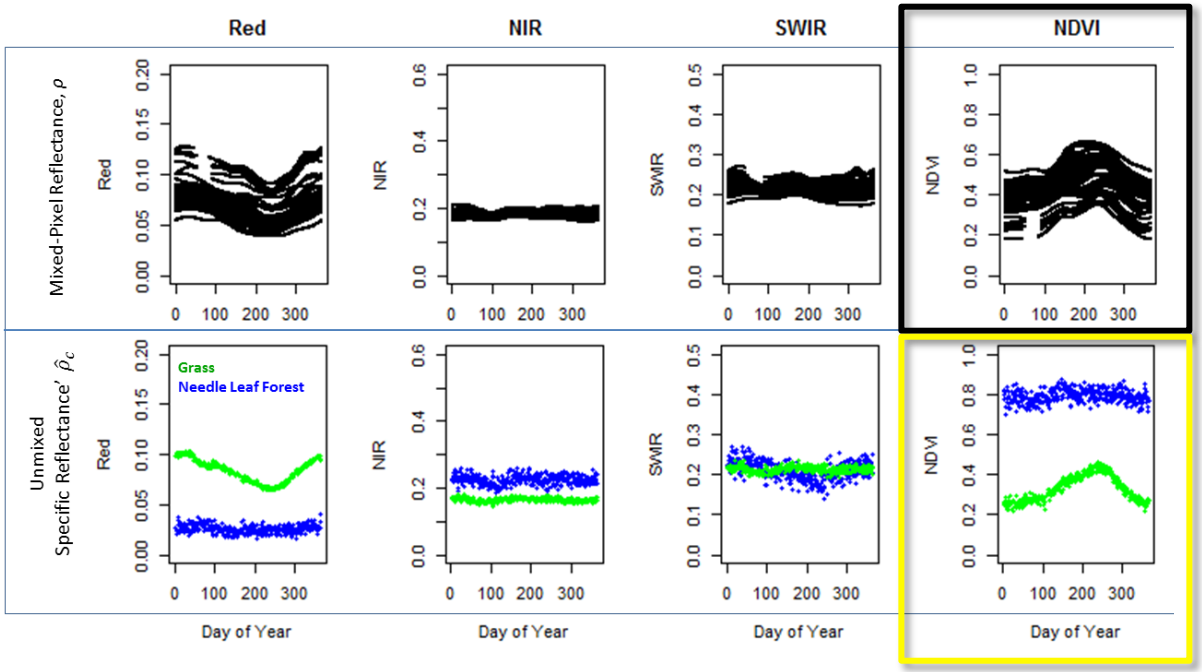
coarse spatial x fine temporal scale

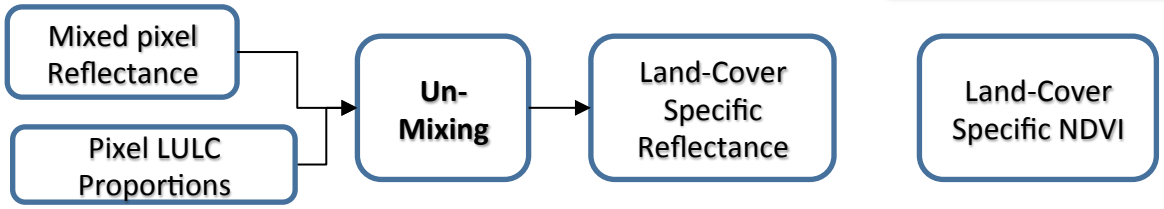


Information loss with pixel size

Extracting plant-specific phenologies from mixed pixels

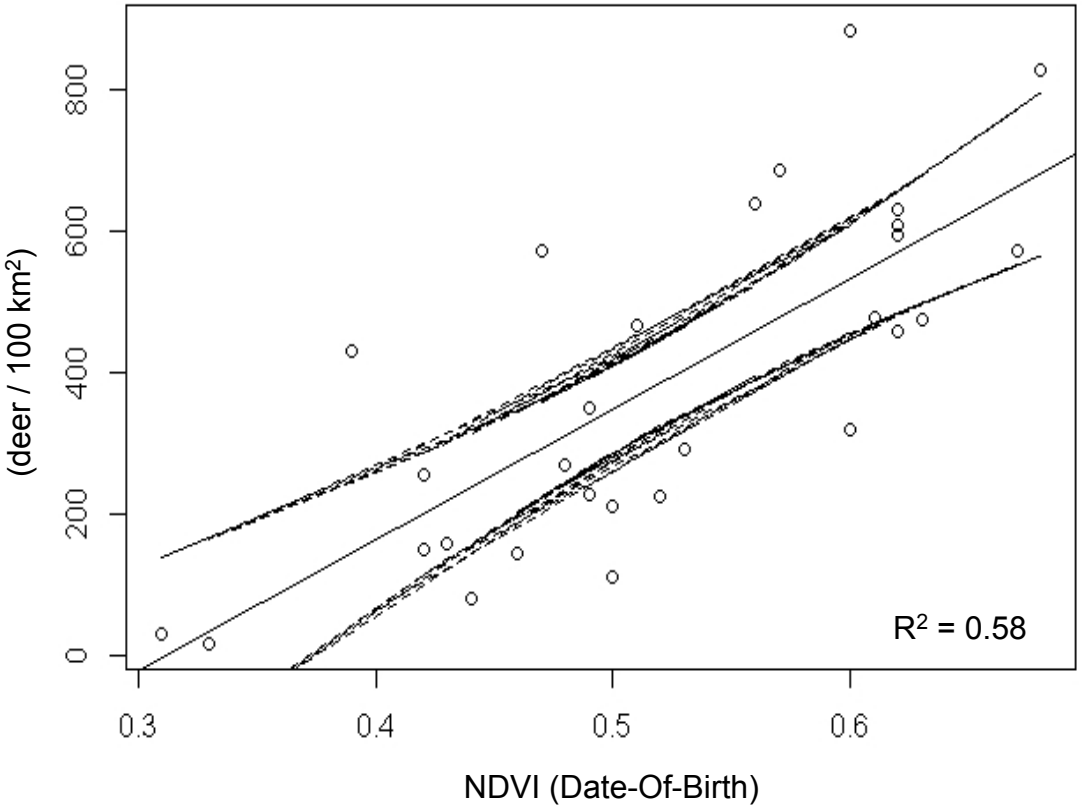
Evergreen-grass savannah

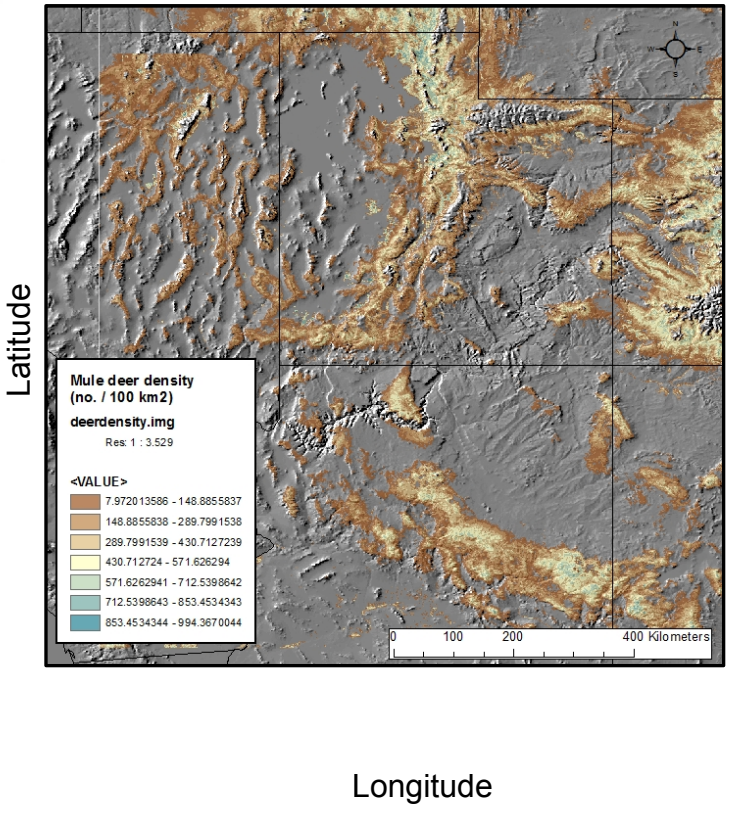




Nagol *et al*. In revision. *Remote Sensing*.

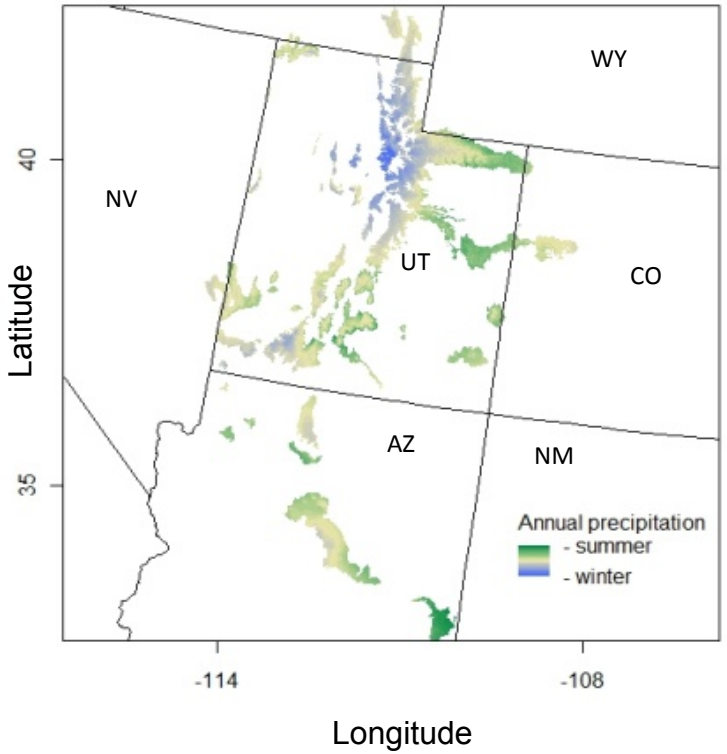
Plant productivity predicts herbivore abundance

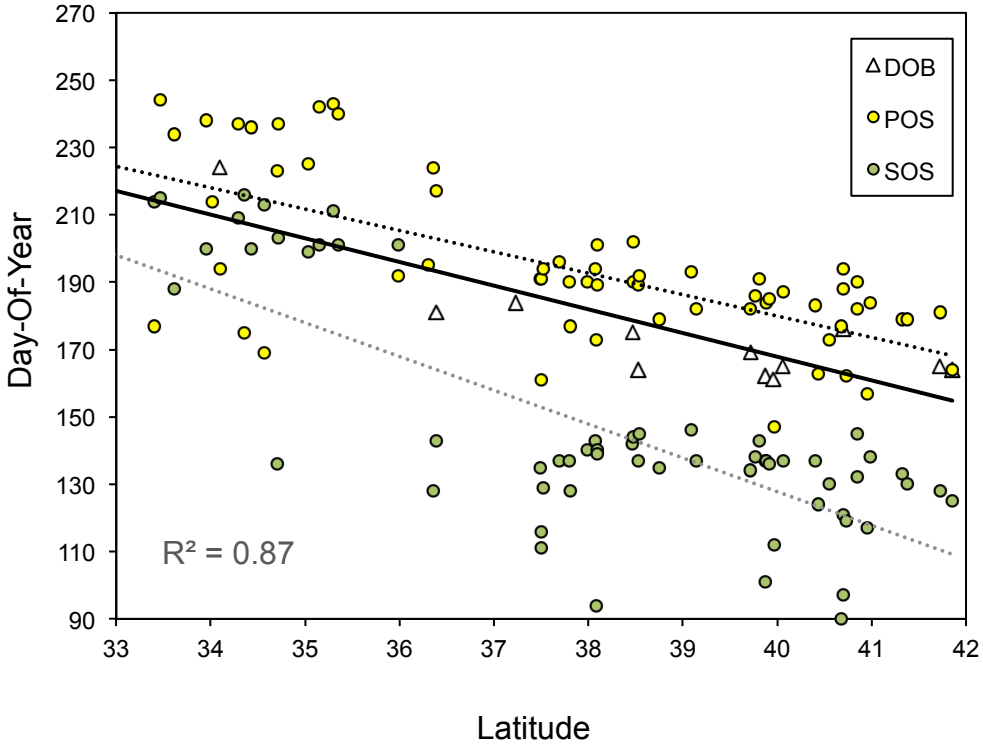




Stoner *et al*. *in prep*.

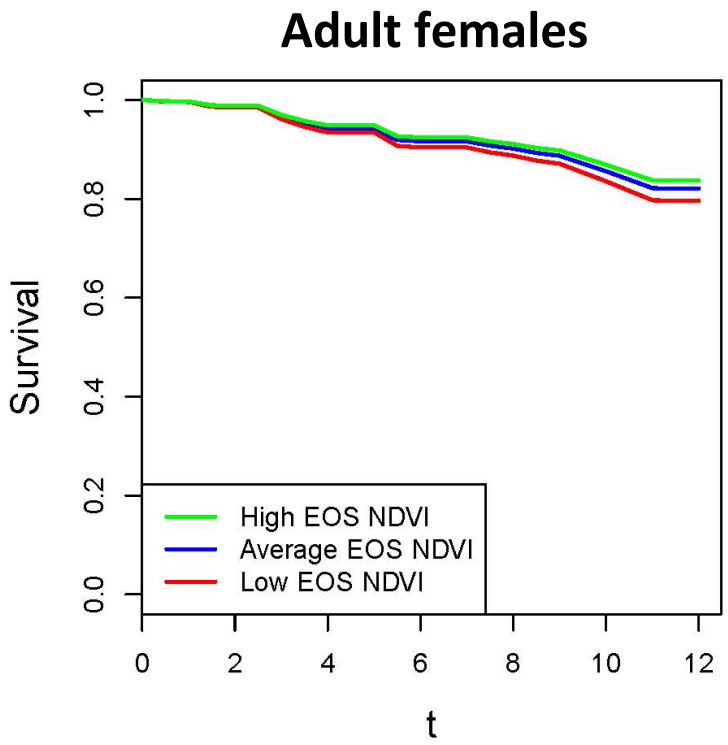
Plant phenology predicts herbivore reproduction

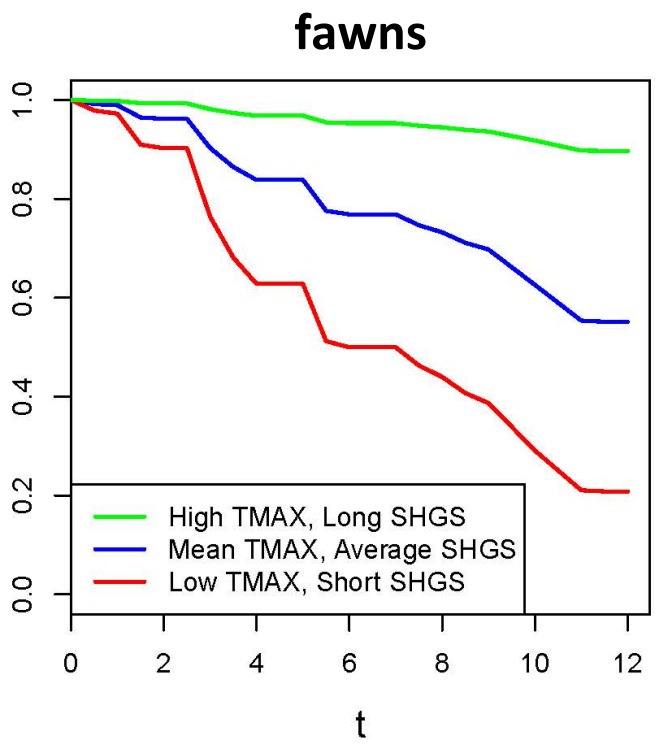




Stoner *et al*. 2016. *PLoS One*.

Plant phenology predicts herbivore survival

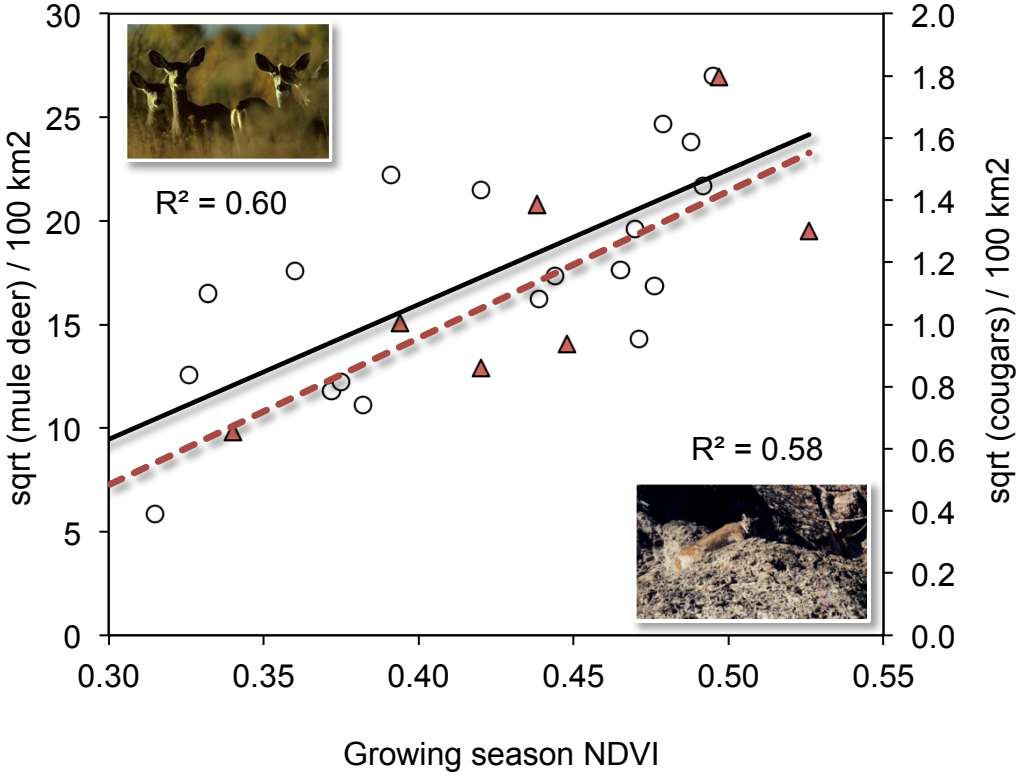


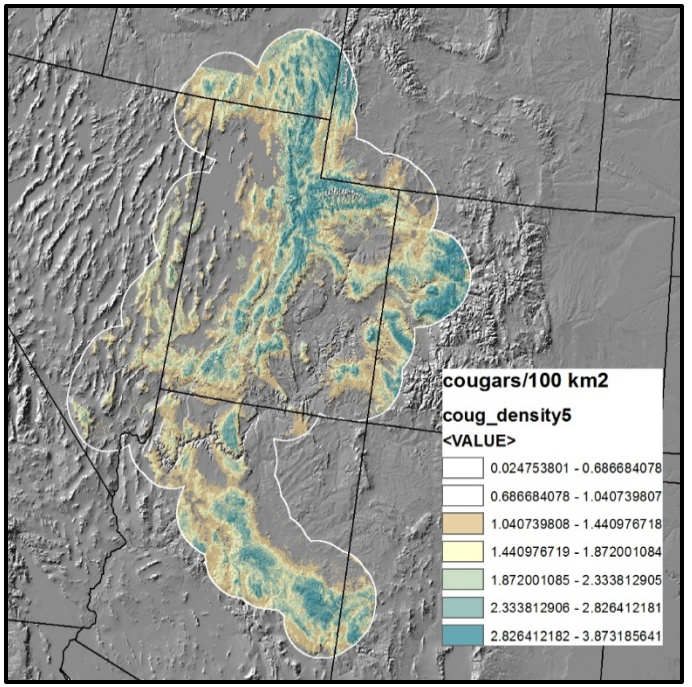


Sims, A. MS thesis. Utah State University. November 2016.

"…Where can we grow deer in the future?"

Plant productivity predicts carnivore abundance





Stoner *et al*. *in prep*.

Conclusions

Ecological

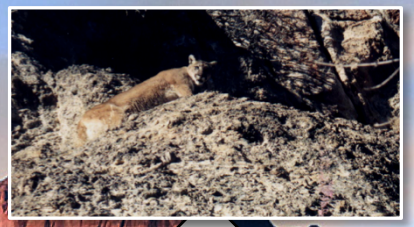
- Climate changes propagate through ecosystems
  - Vegetation: productivity & phenology
  - Herbivores: abundance, demography & behavior
  - Carnivores: abundance

Technical

- Consistent, long-term records are key
  - Vegetation composition & structure
    - Landsat, lidar, radar
  - Plant phenology
    - MODIS & VIIRS
  - Plant chemistry / hyperspectral

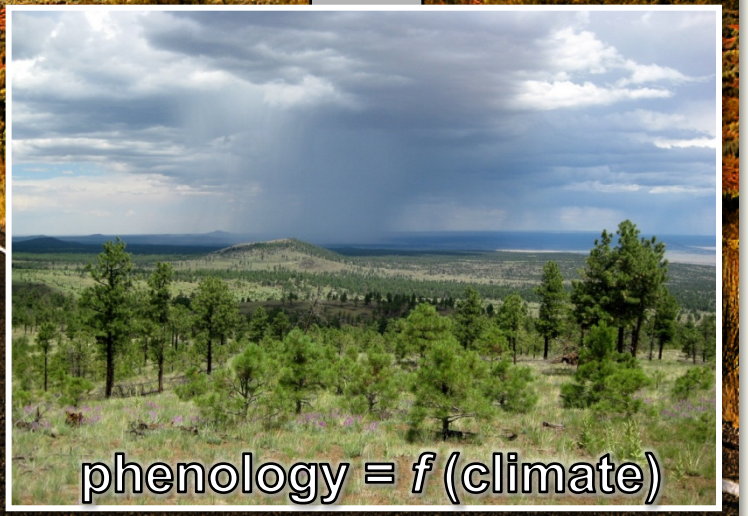
Practical

- Managers need monitoring & forecasts
  - Gradual adoption of satellite data
  - Matching with GPS & population data
  - Strong need to grow research into satellite-based monitoring systems



carnivores = *f* (herbivores)

herbivores = *f* (phenology)



phenology = *f* (climate)

Looking forward

- Economic impacts of wildlife
  - Wildlife-based economies
    - $150 billion / yr
    - > 600,000 jobs
    - ~ 1% of GDP
  - Agricultural & property damage
    - $5 billion / yr
  - Game species are conservation umbrellas
- The realities of land management
  - Agencies need to monitor and predict
  - Budgets not keeping pace with costs
  - Managers need systematic data and tools
    - Research
    - Monitoring
    - Communication

US Fish & Wildlife Service. 2012. National survey of fishing, hunting, and wildlife-associated recreation.


Questions?